NASA
Technical
Memorandum

NASA TM-100346

FY 1988 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

Compiled by Joyce E. Turner
Management Operations Office

October 1988

National Aeronautics and
Space Administration

George C. Marshall Space Flight Center

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
NASA TM-100346		

4. TITLE AND SUBTITLE	5. REPORT DATE
FY 1988 Scientific and Technical Reports, Articles, Papers, and Presentations	October 1988
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Compiled by Joyce E. Turner	8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812	10. WORK UNIT NO.
	11. CONTRACT OR GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D.C. 20546	13. TYPE OF REPORT & PERIOD COVERED Technical Memorandum
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared by Management Operations Office, Administrative Operations Office.

16. ABSTRACT

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY 88. It also includes papers of MSFC contractors.

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17. KEY WORDS	18. DISTRIBUTION STATEMENT
	Unclassified – Unlimited

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	66	NTIS

FOREWORD

In accordance with the NASA Space Act of 1958, the MSFC has provided for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

Since July 1, 1960, when the George C. Marshall Space Flight Center was organized, the reporting of scientific and engineering information has been considered a prime responsibility of the Center. Our credo has been that "research and development work is valuable, but only if its results can be communicated and made understandable to others."

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama

FY 1988 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

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TM-100314 October 1987

Lyman Alpha SMM/UVSP Absolute Calibration and Geocoronal Correction. Juan M. Fontenla and Edwin J. Reichmann. Space Science Laboratory. N88-12446

Lyman alpha observations from the Ultraviolet Spectrometer Polarimeter instrument of the Solar Maximum Mission spacecraft have been analyzed and provide instrumental calibration details. Specific values of the instrument quantum efficiency, Lyman alpha absolute intensity, and correction for geocoronal absorption are presented.

TM-100315 October 1987

Development of Optical Modulators for Measurements of Solar Magnetic Fields - Center Director's Discretionary Fund Final Report. E. A. West and J. E. Smith. Space Science Laboratory. N88-13016

The measurement of polarized light allows solar astronomers to infer what the magnetic field is on the Sun. The accuracy of those measurements is dependent on the stable retardation characteristics of the polarization modulators used to minimize the atmospheric effects that are seen in ground-based observations. This report describes the work by the Space Science Laboratory at Marshall Space Flight Center as part of the Center Director's Discretionary Fund to improve two types of polarization modulators. As a result of this program, the timing characteristics for both electrooptic crystals (KD*Ps) and liquid crystal devices (LCDs) have been studied and will be used to enhance the capabilities of the MSFC Vector Magnetograph.

TM-100316 December 1987

Space Shuttle Main Engine Fuel Preburner Augmented Spark Igniter Shutdown Detonations. C. E. Dexter and T. D. McCay. Propulsion Laboratory. X88-10128

Detonations were experienced in the Space Shuttle Main Engine fuel preburner (FPB) augmented spark igniter (ASI) during engine cutoff. Several of these resulted in overpressures sufficient to damage the FPB ASI oxidizer system. The detonations initiate in the FPB ASI oxidizer line when residual oxidizer (oxygen) in the line mixes with backflowing fuel (hydrogen) and detonates. This report reviews the damage history to the FPB ASI oxidizer system, an engineering assessment of the problem cause, a verification of the mechanisms, the hazards associated with the detonations, and the solution implemented.

TM-100317 December 1987

Cellular Solidification in a Monotectic System - Center Director's Discretionary Fund Final Report. W. F. Kaukler and P. A. Curreri. Space Science Laboratory. N88-15027

Succinonitrile-glycerol, SN-G, transparent organic monotectic alloy is studied with particular attention to cellular growth. The phase diagram is determined, near the monotectic composition, with greater accuracy than previous studies. A solidification interface stability diagram is determined for planar growth. The planar-to-cellular transition is compared to predictions from the Burton, Primm, Schlichter theory. A new technique for determining the solute segregation by Fourier transform infrared spectroscopy is developed. Proposed models that involve the cellular interface for alignment of monotectic second-phase spheres or rods are compared with observation.

TM-100318 October 1987

FY 1987 Scientific and Technical Reports, Articles, Papers, and Presentations. Compiled by Joyce E. Turner. Management Operations Office. N88-16578

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY 87. It also includes papers of MSFC contractors.

After being announced in STAR, all of the NASA series reports may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

The information in this report may be of value to the scientific and engineering community in determining what information has been published and what is available.

TM-100319 February 1988

An Analysis of Penetration and Ricochet Phenomena in Oblique Hypervelocity Impact. William P. Schonberg, Roy A. Taylor, and Jennifer R. Horn. Materials and Processes Laboratory. N88-18004

This report describes the results of an experimental investigation of phenomena associated with the oblique hypervelocity impact of spherical projectiles on multi-sheet aluminum structures. A model that can be employed in the design of meteoroid and space debris protection systems for space structures is developed. The model consists of equations that relate crater and perforation damage of a multi-sheet structure to parameters such as projectile size, impact velocity, and trajectory obliquity. The equations are obtained through a regression analysis of oblique hypervelocity impact test data. This data shows that the response of a multi-sheet structure to oblique impact is significantly different from its response to normal hypervelocity impact. It was found that obliquely incident projectiles produce ricochet debris that can severely damage panels or instrumentation located on the exterior of a space structure. Obliquity effects of high-speed impact must, therefore, be considered in the design of any structure exposed to the meteoroid and space debris environment.

TM-100320 February 1988

Emulating a Flexible Space Structure: Modeling. H. B. Waites, S. C. Rice, and V. L. Jones. Structures and Dynamics Laboratory. N88-16812

Control Dynamics, in conjunction with Marshall Space Flight Center, has participated in the modeling and testing of Flexible Space Structures for the past several years. Through the series of configurations tested and the many techniques used for collecting, analyzing, and modeling the data; many valuable insights have been gained and important lessons learned. This paper discusses the background of the Large Space Structure program, Control Dynamics' involvement in testing and modeling of the configurations (especially the ACES configuration), the results from these two processes, and insights gained from this work.

TM-100321 February 1988

Cost Effective Development of a National Test Bed. H. B. Waites, V. L. Jones, and S. M. Seltzer. Structures and Dynamics Laboratory. N88-19585

For several years, the Marshall Space Flight Center has pursued the coordinated development of a Large Space Structures (LSS) National Test Bed for the investigation of numerous technical issues involved in the use of LSS in space. This paper describes the origins of this development, the current status of the various test facilities and the plans laid down for the next five years' activities. Particular emphasis on the control and structural interaction issues has been paid so far; however, immediately emerging are user applications (such as the proposed pinhole occulter facility). In the immediate future, such emerging technologies as smart robots and multibody interactions will be studied. These areas are covered in this report.

TM-100322 March 1988

Test Results of High-Voltage, High-Power, Solid-State Remote Power Controllers. Yvette Binford Johnson and Robert E.

Kapustka. Information and Electronic Systems Laboratory. N88-23085

This report discusses the results of testing high-voltage, high-power, solid-state remote power controllers (RPC) using RPC's designed and built by John C. Sturman at the Lewis Research Center, Cleveland, Ohio, and utilizing the Autonomously Managed Power Systems (AMPS) breadboard/test facility. These test results are used to determine usefulness of the RPC's for future applications in high voltage Direct-Current space power.

TM-100324 March 1988

Analysis of Contamination Data Recorded by the IECM Camera/Photometer. K. Stuart Clifton and Carl M. Benson. Space Science Laboratory. N88-21246

The Camera/Photometer was one of ten instruments comprising the Induced Environment Contamination Monitor (IECM) developed to monitor the contamination about the space shuttle Orbiter during early shuttle missions. This experiment consisted of two motion picture cameras, integrating photometers, and associated electronics enclosed in pressurized canisters and separated by 40 cm in order to make stereoscopic observation of particulates. The objectives of the experiment were to record the occurrence of particulates and to determine their velocities, sizes, and origins, as well as to measure the background brightness due to unresolved particles. Particle tracks were detected on over 1,800 data frames recorded during continuous operations throughout STS-2, -3, -4, and -9. This report discusses the analysis techniques employed in reducing the subsequent results, with an emphasis placed on particle size and velocity data. It also describes the operation of the overall experiment and some of the results obtained.

TM-100325 March 1988

Analysis of the Performance of the Space Ultravacuum Research Facility in Attached and Free-Flyer Mode. Robert J. Naumann. Space Science Laboratory. N88-26387

The old concept of using the wake of a spacecraft to obtain an ultrahigh vacuum is revisited with a somewhat different emphasis. Since it is possible to configure a wake shield so that a surface of interest does not subtend any walls that could become contaminated, it appears that it should be possible to achieve a contamination-free, ultrahigh vacuum capability with infinite pumping speed even in the presence of high heat loads and moderate gas loads. With the new interest in developing thin films with precision controlled synthetic microstructures such as superlattices, mixed metal oxide high temperature superconductors, rare-Earth magneto-optical devices, and nano-crystalline alloys, the ability to work with a variety of different materials without cross contamination should be of significant importance. This paper analyzes the performance of the conceptual design for a Space Ultravacuum Research Facility (SURF), both in a Shuttle-attached mode and as a free-flyer. It is shown that even in the Shuttle-attached mode, it should be possible to obtain vacuum levels equivalent to 10^{-10} Torr with O and N_2 as the primary constituents. This should be sufficient to demonstrate the feasibility of the concept, particularly the infinite pumping speed and virtual elimination of contamination aspects. As a free-flyer the SURF will be limited primarily by the gas load associated with the process being performed. For chemical beam epitaxy (CBE) it is shown that equivalent vacuum levels of 10^{-14} Torr should be possible at 300 km.

TM-100326 April 1988

LEWIS 2 - A Propulsion Design Program for Required Thrust at Minimum Pressure. Walter W. Brandon. Program Development Directorate. X88-10287

This report describes the use of the NASA-LEWIS Chemical Equilibrium Program to design

rocket nozzles for the minimum pressure consistent with specified values of nozzle exit diameter, combustion-gas flow rate, and vacuum specific impulse. Since the latter two quantities are the components of vacuum thrust, parametric studies of constant-thrust conditions may also be made. Although the computer implementation employed is described in an appendix, necessary calculations can also be made with an iterative method requiring no computer capability beyond that of running the NASA-LEWIS program itself. This iteration is also described in an appendix.

The procedure developed was originally programmed on a CDC 760 computer under the designation MINPRESS. The procedure has now been programmed on the VAX computer at Marshall Space Flight Center as LEWIS 2. Both versions generate tables of nozzle expansion and pressure ratios so that the tabular inputs described in this documentation are not required.

Application of the LEWIS 2 program to the parametric design of possible liquid booster alternatives to the solid boosters of the Space Shuttle is illustrated in Appendix V.

TM-100329 April 1988

Effects of Natural Environment on First Generation Solid Rocket Booster Thermal Protection System Materials. D. D. Webb. Materials and Processes Laboratory.

N88-24113

This report summarizes the effort to demonstrate, by real-time exposure, the effects of the natural environment at Kennedy Space Center, Florida, upon the Thermal Protection System (TPS) of the Solid Rocket Booster (SRB), and to verify that the overall SRB TPS configuration meets all requirements for resistance to the conditions associated with outdoor weathering, including: (1) solar radiation, (2) temperature, (3) humidity, (4) precipitation, (5) wind, (6) sand/dust abrasion, (7) static electricity, (8) salt spray, (9) fungus, and (10) atmospheric oxidants.

The evaluation criterion for this project was based upon flatwise tensile properties, visual inspection, color change, and thermal performance. Based upon the evaluation of the changes in these properties, it is concluded that properly applied and topcoat-protected TPS can satisfactorily withstand the conditions of the natural environment at KSC for exposures up to six months.

TM-100330 May 1988

Carbon-Carbon Technology (CCT) Sensitivity Study for PAM-D Nozzle. Henry Lee. Structures and Dynamics Laboratory.

X88-10288

This report relates the analytical sensitivity studies accomplished on a carbon-carbon nozzle exit cone especially built and hot fired for NASA-MSFC under an engineering verification and technology program. The analysis was performed using an incremental nonlinear axisymmetric continuum element code developed explicitly to handle composite involute construction designs. Material and geometric parameters are varied, with the effect of these changes noted at several key structural locations along the carbon-carbon exit cone.

TM-100331 June 1988

Graphics Software Tool for VT Terminals (VTGRAPH). Caroline Wang. Information and Electronic Systems Laboratory.

N88-24201

VTGRAPH is a graphics software tool for using DEC/VT or VT compatible terminals. It allows the user to deal with computer environments which use VT terminals for window management and graphics systems.

VTGRAPH was developed using the Re'Gis Graphics set and it was written in FORTRAN language. It provides window management and PLOT10-like package plus color or shade capability.

TM-100332 June 1988

Structural Margins Assessment Approach. Robert S. Ryan. Structures and Dynamics Laboratory. N88-24672

This document contains a general approach for structural design and verification used for determining the structural margins of the space vehicle elements under Marshall Space Flight Center (MSFC) management. The Space Shuttle results and organization will be used as illustrations for techniques discussed. Discussed are (1) the system analyses performed or to be performed by and (2) element analyses performed by MSFC and their contractors. Analysis approaches and their verification will be addressed. The Shuttle procedures are general in nature and apply to other than Shuttle space vehicles.

TM-100333 May 1988

The Influence of Growth Rate on Fatigue Properties in a Directionally Solidified Superalloy - Center Director's Discretionary Fund Final Report. M. H. McCay, D. D. Schmidt, W. D. Hamilton, W. S. Alter, and R. A. Parr. Materials and Processes Laboratory. X88-10357

The nickel-based superalloy MAR-M246(Hf) was studied to determine the effect of various growth rates on the alloy's morphology and fatigue properties. Increased growth rates in the MAR-M246(Hf) produced a more dendritic microstructure that was expected to increase fatigue life. Even though the Weibull analysis results showed a longer characteristic life (η) for the fast rate, β was much smaller, thus indicating less predictable fatigue properties. This was related to the increasing carbide and eutectic contents with increasing growth rate.

TM-100334 May 1988

Heat Treatment Study of MAR-M246(Hf) - Center Director's Discretionary Fund Final Report. M. H. McCay, D. D. Schmidt, W. S. Alter, W. D. Hamilton, and R. A. Parr. Materials and Processes Laboratory. X88-10358

The nickel-base superalloy MAR-M246(Hf) was studied to determine an alternate heat treatment that could enhance the alloy's morphology and fatigue properties by optimizing the solution and aging trestment variables. Several solution treatments and combinations of solution and aging treatments were studied and compared to the standard heat treatment for beneficial changes in the γ' and γ-γ' eutectic morphology. The microstructure was found to be more uniform when the solution treatment time was reduced to 1 hour at 1221°C. The Weibull analysis performed on fatigue data results shows slightly improved fatigue properties for this reduced solution treatment of 1 hour at 1221°C with standard aging.

TM-100335 May 1988

Description of Graphics Translation Software Between Integraph and Tektronix Systems. Tom Rieckhoff, Jeff Hixson, and Mark Covan. Propulsion Laboratory. N88-24202

The requirement for Marshall Space Flight Center's Photo Analysis to use existing three-dimensional Intergraph graphic files on an existing Tektronix 4129 three-dimensional graphics workstation and the unavailability of an off-the-shelf Intergraph to Tektronix translator required the development of such a translator. Using the output of Intergraph's standard interchange format converter, the three-dimensional graphic information of Intergraph's files are reformatted and compressed. The three-dimensional image is reconstructed using Tektronix's software terminal interface graphic library (STI).

TM-100336 June 1988

IPS Guidestar Selection for Stellar Mode (ASTRO). Larry Mullins and Lewis Wooten. Systems Analysis and Integration Laboratory. N88-27181

This report describes how guide stars are selected for the Optical Sensor Package (OSP) for

the Instrument Pointing System (IPS) when it is operating in the stellar mode on the ASTRO missions. It also describes how the objective loads are written and how the various roll angles are related; i.e., the celestial roll or position angle, the objective load roll angles, and the IPS gimbal angles. There is a brief description of how the IPS operates and its various modes of operation; i.e., IDOP, IDIN, and OSPCAL.

TM-100337 July 1988

Modeling, Designing, and Simulating a Pointing Control System for Balloon-Borne Solar Experiments. W. D. Lightsey and M. E. Polites. Structures and Dynamics Laboratory.

N88-28300

A simplified model of a pointing control system for balloon-borne solar experiments is chosen. Equations of motion for this model are derived and a feedback control law is defined. A digital computer simulation of the system is developed. Simulation results show favorable system response characteristics.

TM-100338 August 1988

An Application of "High Authority/Low Authority Control" and "Positivity." S. M. Seltzer, D. Irwin, D. Tollison, and H. B. Waites. Structures and Dynamics Laboratory.

Control Dynamics Company (CDy), in conjunction with NASA Marshall Space Flight Center (MSFC), has supported the U.S. Air Force Wright Aeronautical Laboratory (AFWAL) in conducting an investigation of the implementation of several Department of Defense controls techniques. These techniques are to provide vibration suppression and precise attitude control for flexible space structures. AFWAL issued a contract to Control Dynamics to perform this effort under the Active Control Technique Evaluation for Spacecraft (ACES) Program. Dr. Henry B. Waites (MSFC) was the Principal Investigator, Dr. George B. Doane III (CDy) was the Program Manager, and Dr. R. Dennis Irwin (formerly CDy, presently Ohio University) was the Project Leader. The "High Authority Control/Low Authority Control" (HAC/LAC) and "Positivity" controls techniques, which were cultivated under the DARPA Active Control of Space Structures (ACOSS) Program, were applied to a structural model of the NASA/MSFC Ground Test Facility ACES configuration. Mr. Danny K. Tollison performed the HAC/LAC evaluation, and Mr. Jeffrey Lucas performed the Positivity evaluation. The control system designs were accomplished, and linear post-analyses of the closed-loop systems are provided. The control system designs take into account effects of sampling and delay in the control computer. Nonlinear simulation runs were used to verify the control system designs and implementations in the facility control computers. Finally, test results are given to verify operations of the control systems in the test facility.

TM-100339 August 1988

NASA Marshall Space Flight Center Solar Observatory Report - January-March 1988. James E. Smith. Space Science Laboratory.

This report provides a description of the NASA Marshall Space Flight Center's Solar Vector Magnetograph Facility and gives a summary of its observations and data reduction during January-March 1988. The systems that make up the facility are a magnetograph telescope, an H-alpha telescope, a Questar telescope, and a computer center. The data are represented by longitudinal contours with azimuth plots.

TM-100340 September 1988

A Review of Melt and Vapor Growth Techniques for Polydiacetylene Thin Films for Nonlinear Optical Applications. B. G. Penn, A. Shields, and D. O. Frazier. Space Science Laboratory.

Methods for the growth of polydiacetylene thin films by melt and vapor growth and their

subsequent polymerization are summarized. Films with random orientations were obtained when glass or quartz were used as substrates in the vapor growth process. Oriented polydiacetylene films were fabricated by the vapor deposition of diacetylene monomer onto oriented polydiacetylene on a glass substrate and its subsequent polymerization by UV light. A method for the growth of oriented thin films by a melt-shear growth process as well as a method of film growth by seeded recrystallization from the melt between glass plates, that may be applied to the growth of polydiacetylene films, are described. Moreover, a method is presented for the fabrication of single crystal thin films of polydiacetylenes by irradiation of the surface of diacetylene single crystals to a depth between 100 and 2000 Å.

TM-100341 September 1988

A Preliminary Review of Organic Materials Single Crystal Growth by the Czochralski Technique. B. G. Penn. A. W. Shields, and D. O. Frazier. Space Science Laboratory.

The growth of single crystals of organic compounds by the Czochralski method has been reviewed. From the literature, single crystals of benzil, a nonlinear optical material with a d_{11} value of 11.2 ± 1.5 x d_{11} value of α quartz, has fewer dislocations than generally contained in Bridgman crystals. More perfect crystals were grown by repeated Czochralski growth. This consists of etching away the defect-containing portion of a Czochralski grown crystal and using it as a seed for further growth. Other compounds used to grow single crystals are benzophenone, 12-tricosanone (laurone), and salol. The physical properties, growth apparatus, and processing conditions presented in the literature are discussed. Moreover, some of the possible advantages of growing single crystals of organic compounds in microgravity to obtain more perfect crystals than on Earth are reviewed.

TM-100342 September 1988

Power Quality Load Management for Large Spacecraft Electrical Power Systems. Louis F. Lollar. Information and Electronic Systems Laboratory.

In December 1986, a Center Director's Discretionary Fund (CDDF) proposal was granted to study power system control techniques in large space electrical power systems. This paper presents the accomplishments in the area of power system control by power quality load management. In addition, information concerning the distortion problems in a 20 kHz ac power system is presented.

TM-4014 September 1987

Analysis of the Bivariate Parameter Wind Differences Between Jimsphere and Windsonde. Michael Susko. Structures and Dynamics Laboratory. N88-10461

The purpose of this report is to present an analysis of the bivariate parameter differences between the FPS-16 Radar/Jimsphere and the Meteorological Sounding System (MSS) Windsonde. The Jimsphere is used as the standard to measure the ascent wind loads during the Space Shuttle launches at Kennedy Space Center, Florida, and the Windsonde is the backup system. In addition, in the report a discussion of the terrestrial environment (below 20 km) and a description of the Jimsphere and Windsonde wind sensors are given. Computation of the wind statistics from 64 paired Jimsphere and Windsonde balloon releases in support of 14 Space Shuttle launches shows good agreement between the two wind sensors.

The computed difference values in m/s of the mean zonal wind ($\bar{u}$) and mean meridional wind ($\bar{v}$) of the Jimsphere and Windsonde at 500 m intervals from the surface to 16 km shows good agreement between the wind components. The ($\bar{u}$) and ($\bar{v}$) mean differences for the 64 paired observations were 0.16 and 0.22 m/s, respectively, while the standard deviations of the mean differences of $\bar{u}$ and $\bar{v}$ were 1.38 and 1.73 m/s, respectively.

From the analysis of the buildup and back-off data for various scales of distance and the comparison of the cumulative percent frequency (CPF) versus wind speed change, it is shown that the wind speed change for various scales of distances (m) 100, 200, 400, 600, 800, 1000, 2000, 3000, and 5000 for the Jimsphere and Windsonde compare favorably. For example, the average altitude, where the greatest buildup occurred for all the scales of distances was at 10,427 m for the Jimsphere, 10,529 m for the Windsonde, and 10,474 m for the Jimsphere/Windsonde pairs, a range of only 102 m. The S.D. of these parameters were 2999, 3029, and 3007 m, less than a 50 m difference.

The variance difference of energy for the Power Spectral Density parameters for the u and v components of the Jimsphere and Windsonde was less than ± 0.02 m^2/sec^2. This showed very good agreement between the Jimsphere Wind sensor and its backup, the Windsonde in the all-important variance parameter, the energy difference between the Jimsphere and Windsonde at various wavenumbers or wavelengths.

TM-4035 March 1988

Description of MSFC Engineering Photographic Analysis. Jim Earle and Frank Williams. Propulsion Laboratory.

N88-18900

Utilizing a background that includes development of basic launch and test photographic coverage and analysis procedures, the MSFC Photographic Evaluation Group has built a field of experience that enables it to effectively satisfy MSFC's engineering photographic analysis needs. Combining the basic soundness of reliable, proven techniques of the past with the newer technical advances of computers and computer-related devices, the MSFC Photo Evaluation Group is in a position to continue to provide photo and video analysis service center-wide and NASA-wide to provide an improving photo analysis product to meet the photo evaluation needs of the future; and to provide new standards in the state-of-the-art of photo analysis of dynamic events.

TM-4048 June 1988

The SAMEX Vector Magnetograph - A Design Study for a Space-Based Solar Vector Magnetograph. M. J. Hagyard, G. A. Gary, and E. A. West. Space Science Laboratory.

N88-25424

This report presents the results of a pre-phase A study performed by the Marshall Space Flight Center's (MSFC) Solar Science Branch for the Air Force Geophysics Laboratory (AFGL) to develop a design concept for a space-based solar vector magnetograph and hydrogen-alpha telescope. As two of the three core instruments for the proposed AFGL Solar Activity Measurements Experiments (SAMEX) satellite, these instruments were designed to provide high-resolution observations of the solar magnetic field in the photosphere and chromosphere. The MSFC ground-based vector magnetograph served as the prototype for the space-based instrument. The primary scientific objective of the SAMEX mission is to understand the role of the Sun's magnetic field in the physics of solar flares. This and other related objectives developed for the SAMEX mission imposed the following instrumental requirements on the vector magnetograph: (1) a temporal resolution of <5 min, (2) a field of view of 4.3 x 8.5 arc min to cover most active regions, (3) a spatial resolution of 0.5 arc sec, (4) a spectral range covering the wavelengths from 524.3 to 525.4 nm, and (5) a polarimetric sensitivity of 10^{-4} to measure the solar magnetic field with greater accuracy than has been done with any other system. The polarimetric accuracy of 10^{-4} was obtained through the use of specially designed optical coatings on the fore-optics and the design of a unique polarimeter. To obtain observations of entire active regions with 0.5 arc sec spatial resolution in less than 5 min required the design of a large-array, charge coupled device

(CCD) detector with parallel processing electronics. This report discusses the SAMEX scientific objectives and presents the designs of the optics, polarimeter, spectral filters, and detector that are required to meet these objectives. The report also discusses the numerous trade-offs among spatial resolution, areal coverage, temporal resolution, spectral response, and telemetry that must be considered in achieving the design goals. Spacecraft and mission requirements and requirements for data reduction and analysis are also covered in the report.

TM-4059 August 1988

The Marshall Space Flight Center KC-135 Microgravity Test Program for FY84-86. Edited by R. E. Shurney. Associate Director for Space Systems. N88-28136

Marshall Space Flight Center supported 122.6 hours of flight time in the KC-135 aircraft based at Ellington Field, in Houston, Texas, from FY84 through FY86. During this period, 17 different experiments were flown with several repeating or continuous research, having accumulated over 1554 parabolas. During these parabolas, there were various gravity levels from near zero to 2.2. The number of hours and parabolas increased significantly over past years and testifies to the increasing interest in the KC-135 aircraft usage.

This report compiles the results of tests by various experimenters in the microgravity aircraft program at Marshall Space Flight Center for this period.

TM-4066 September 1988

Wind Measurements by Electromagnetic Probes. Michael Susko. Structures and Dynamics Laboratory.

The purpose of this report is to present the emerging technology of electromagnetic probing of the atmosphere to measure winds used in space vehicle's ascent winds load calculations. The frequency range, altitude, and resolution for the following probes are presented: lidars, microwave radars, and clear-air Doppler radars (popularly known as wind profilers).

The electromagnetic probing of the atmosphere by clear-air radars and lasers is the new technology to supplement balloon-borne wind sensors which are used to determine ascent wind loads of space vehicles. The electromagnetic probes measure the wind velocity using the Doppler effect. This is the radar technology used in MSFC's Radar Wind Profiler, and is similar to the technology used in conventional Doppler systems except the frequency is generally lower, antenna is bigger, and dwell time is much longer. Designed for unattended and automated instrumentation in providing measurements of the wind in the troposphere, the profiler employs Doppler radar technology and is currently being put in operation at NASA's Kennedy Space Center, Florida.

TM-4076 September 1988

Rechargeable Metal Hydrides for Spacecraft Application. J. L. Perry. Structures and Dynamics Laboratory.

Storing hydrogen on board the Space Station presents both safety and logistics problems. Conventional storage using pressurized bottles requires large masses, pressures, and volumes to handle the hydrogen which will be used by experiments in the U.S. Laboratory Module and residual hydrogen generated by the ECLSS. Rechargeable metal hydrides may be competitive with conventional storage techniques. The basic theory of hydride behavior is presented and the engineering properties of $LaNi_5$ are discussed to gain a clear understanding of the potential of metal hydrides for handling spacecraft hydrogen resources. Applications to the Space Station and the safety of metal hydrides are presented and compared to conventional pressurized storage. This comparison indicates metal hydrides may be safer and require a lower pressure, less volume, and less mass to store an equivalent mass of hydrogen.

TP-2777 October 1987

Preparative Electrophoresis for Space. Percy H. Rhodes and Robert S. Snyder. Space Science Laboratory. N88-10977

A basic premise of continuous flow electrophoresis is that removal of buoyancy-induced thermal convection caused by axial and lateral temperature gradients will result in ideal performance of these instruments in space. Although these gravity dependent phenomena disturb the rectilinear flow in the separation chamber when high voltage gradients and/or thick chambers are used, distortion of the injected sample stream due to electrohydrodynamic effects causes major broadening of the separated bands.

Although the electrophoresis separation process is simple in concept, flows local to the sample filament produced by the applied electric field have not been considered. These electrohydrodynamic flows, formulated by G. I. Taylor in 1965 for drops suspended in various liquids, distort the sample stream and limit the separation. In addition, electroosmosis and viscous flow, which are inherent in the continuous flow electrophoresis device, combine to further disturb the process. Electroosmosis causes a flow in the chamber cross section which directly distorts the sample stream, while viscous flow causes a parabolic profile to develop in the flow plane. This flow profile in turn distorts migration by causing a varying residence time across the thickness of the chamber. Thus, sample constituents at the center plane will be in the electric field a shorter time and hence move less than comparable constituents closer to the chamber wall.

A moving wall concept is being proposed for space which will eliminate and/or control all of the above-mentioned disturbances. The moving wall will entrain the fluid to move as a rigid body and hence produce a constant residence time for all samples distributed across the chamber thickness. By aligning the moving wall at an angle to the chamber axis, a component of the moving wall motion can be made to oppose and hence cancel the electroosmotic flow. In the absence of electrokinetic effects, i.e., electroosmosis, the electro-hydrodynamical effect manifests itself as a ribbon, being either vertical (perpendicular to the electric field) or horizontal (aligned with the electric field) depending on the ratio of conductivity of the sample to that of the buffer. Therefore, by using low conductivity sample solutions to provide a vertical ribbon, the moving wall concept should produce distortion-free separations.

The moving wall electrophoresis chamber can only be operated in space because there is no viscous flow in the chamber to stabilize against thermal convection. Laboratory prototype instruments have been built which confirm the sensitivity of their operation. These prototypes have also identified engineering problems such as liquid seals. However, the moving wall electrophoresis system is a concept designed for space which should permit preparative electrophoresis to attain its potential.

TP-2778 October 1987

Continuous Flow Electrophoresis System Experiments on Shuttle Flights STS-6 and STS-7. Robert S. Snyder, Percy H. Rhodes, and Teresa Y. Miller. Space Science Laboratory. N88-10978

In 1978, McDonnell Douglas Astronautics Company (MDAC) began discussions with NASA on the opportunities to develop a space continuous flow electrophoresis system (CFES) that would incorporate specific modifications to their laboratory instruments to take advantage of weightlessness. A Joint Endeavor Agreement (JEA) that allocated certain flights on the Space Shuttle to MDAC in return for opportunities for NASA and interested scientists to do research in the MDAC laboratory and on their space instruments was made.

Under terms of the JEA, NASA was provided an opportunity to process two samples on STS-6. All experiment objectives and operational parameters, such as applied field, sample residence time in the field, and buffer composition

had to accommodate the MDAC capabilities and NASA flight constraints. The NASA objectives were formulated so as to include investigation of the sample concentration effects reported by MDAC on STS-4. The specific objectives were (1) to use a model sample material at a high concentration to evaluate the continuous flow electrophoresis process in the MDAC CFES instrument and compare its separation resolution and sample throughput with related devices on Earth and (2) to expand our basic knowledge of the limitations imposed by fluid flows and particle concentration effects on the electrophoresis process by careful design and evaluation of the space experiment. Because the MDAC instrumentation did not include sample mixing facilities, cell separation procedures were precluded and after a variety of soluble materials were considered, hemoglobin and polysaccharide were selected as primary samples. The results from space show a large band spread of the high concentration of the single species of hemoglobin that was principally due to the mismatch of electrical conductivity between the sample and buffer.

The seventh mission of the Space Shuttle carried two additional NASA experiments in the CFES instrument. The major objective was to evaluate the influence of the electrical properties of the sample constituents on the resolution of the continuous flow electrophoresis device. As expected, the polystyrene latex microspheres dispersed in a solution with three times the electrical conductivity of the curtain buffer separated with a significantly larger band spread than in to the second experiment under matched conductivity conditions. The structure of the bands is also different between the samples, and laboratory experiments have been conducted to further evaluate the phenomena affecting the electrophoresis. The analysis of both flight results is nearing completion and a qualitative explanation based upon the non-gravity dependent electrical conductivity mismatch is being developed.

TP-2787 December 1987

Growth of Solid Solution Single Crystals. S. L. Lehoczky and F. R. Szofran. Space Science Laboratory. N88-14212

Based on the thermophysical properties of $Hg_{1-x}Cd_xTe$ alloys, the reasons are discussed for the failure of conventional Bridgman-Stockbarger growth methods to produce high quality homogeneous crystals in the presence of Earth's gravity. The deleterious effects are considered which arise from the dependence of the thermophysical properties on temperature and composition and from the large amount of heat carried by the fused silica ampules. An improved growth method, developed to optimize heat flow conditions, is described and experimental results are presented. The problems associated with growth in a gravitational environment are discussed. The anticipated advantages of growth in microgravity are given and the implications of the requirements for spaceflight experiments are summarized.

TP-2793 February 1988

A Study to Evaluate STS Heads-Up Ascent Trajectory Performance Employing a Minimum-Hamiltonian Optimization Strategy. Sujit Sinha. Propulsion Laboratory. N88-15820

A study was conducted to evaluate the performance implications of heads-up ascent flight design for the Space Transportation System, as compared to the current heads-down flight mode. The procedure involved the use of the Minimum Hamiltonian Ascent Shuttle Trajectory Evaluation program, which is a three-degree-of-freedom moment balance simulation of shuttle ascent. A minimum-Hamiltonian optimization strategy was employed to maximize injection weight as a function of maximum dynamic pressure constraint and Solid Rocket Motor burnrate. Performance Reference Mission Four trajectory groundrules were used in all cases for consistency. The major conclusions are that for heads-up ascent and a mission nominal design maximum dynamic pressure value of 680 psf, the optimum solid motor burnrate is 0.394 ips. This

optimum burnrate produces a performance enhancement of 4293 lbm relative to the baseline heads-down ascent, with 0.368 ips burnrate solid motors and a 680 psf dynamic pressure constraint. However, no performance advantage exists for heads-up flight if the current Solid Rocket Motor target burnrate of 0.368 ips is used. The advantage of heads-up ascent flight employing the current burnrate is that Space Shuttle Main Engine throttling for dynamic pressure control is not necessary.

TP-2807 February 1988

A Generalized Method for Automatic Downhand and Wirefeed Control of a Welding Robot and Positioner. Ken Fernandez and George E. Cook. Information and Electronic Systems Laboratory. N88-17869

This paper describes a generalized method for controlling a six degree-of-freedom (DOF) robot and a two DOF positioner used for arc welding operations. The welding path is defined in the part reference frame, and robot/positioner joint angles of the equivalent eight DOF serial linkage are determined via an iterative solution. Three algorithms are presented: the first solution controls motion of the eight DOF mechanism such that proper torch motion is achieved while minimizing the sum-of-squares of joint displacements; the second algorithm adds two constraint equations to achieve torch control while maintaining part orientation so that welding occurs in the downhand position; and the third algorithm adds the ability to control the proper orientation of a wire feed mechanism used in gas tungsten arc (GTA) welding operations. A verification of these algorithms is given using ROBOSIM, a NASA developed computer graphic simulation software package designed for robot systems development.

TP-2812 March 1988

Further Developments in Exact State Reconstruction in Deterministic Digital Control Systems. Michael E. Polites. Structures and Dynamics Laboratory. N88-18751

This paper presents a more-general version of the ideal state reconstructor for deterministic digital control systems previously developed by Polites. In the original version, measurements prefiltered by a multi-input/multi-output moving-average (MA) process were utilized in the state reconstruction process. In this version, the MA-prefiltered measurements can be supplemented by standard instantaneous measurements. The ideal state reconstructor is so named because: if the plant parameters are known exactly, its output will exactly equal the true state of the plant, not just approximate it. Furthermore, it adds no additional states or eigenvalues to the system. Nor does it affect the plant equation for the system in any way; it affects the measurement equation only. An example is presented which illustrates the procedure for choosing the parameters in it.

TP-2820 May 1988

An Electrochemical Study of Corrosion Protection by Primer-Topcoat Systems on 4130 Steel with AC Impedance and DC Methods. M. J. Mendrek, R. H. Higgins, and M. D. Danford. Materials and Processes Laboratory. X88-10270

In an effort to investigate metal surface corrosion and the breakdown of metal protective coatings, the AC impedance method was applied to six systems of primer coated and primer topcoated 4130 steel. Two primers were used: a zinc-rich epoxy primer and a red lead oxide epoxy primer. The epoxy-polyamine topcoat was used in four of the systems. The EG&G-PARC Model 368 AC impedance measurement system, along with DC measurements with the same system using the polarization resistance method, was used to monitor changing properties of coated 4130 steel disks immersed in 3.5 percent NaCl solutions buffered at pH 5.4 over periods of 40 to 60 days. The corrosion system can be represented

by an electronic analog called an equivalent circuit that consists of resistors and capacitors in specific arrangements. This equivalent circuit parallels the impedance behavior of the corrosion system during a frequency scan. Values for the resistors and capacitors, that can be assigned in the equivalent circuit following a least squares analysis of the data, describe changes that occur on the corroding metal surface and in the protective coatings. Two equivalent circuits have been determined that predict the correct Bode phase and magnitude of the experimental sample at different immersion times. DC corrosion current density data are related to equivalent circuit element parameters. Methods for determining corrosion rate with AC impedance parameters are verified by the DC method.

TP-2821 May 1988

SRM Propellant and Polymer Materials Structural Test Program. Dr. Carleton J. Moore. Structures and Dynamics Laboratory. N88-25013

The SRM propellant and polymer materials structural test program has potentially wide application to the testing and structural analysis of polymer materials and other materials generally characterized as being made of viscoelastic materials. The test program will provide a basis for characterization of the dynamic failure criteria for Solid Rocket Motor (SRM) propellant, insulation, inhibitor, and liners. This experimental investigation will also endeavor to obtain a consistent complete set of materials test data. This test data will be used to improve and revise the presently used theortical math models for SRM propellant, insulation, inhibitor, liners, and seal O-rings.

TP-2842 September 1988

The Hydrides of Titanium and Ti-5Al-2.5Sn. Merlin D. Danford. Materials and Processes Laboratory.

Hydrogen diffusion coefficients in titanium and Ti-5Al-2.5Sn alloys, as obtained by electrochemical measurements, have been determined at 25°C. Also, electrochemical measurements using cylindrical samples have indicated that the initial hydrogen distributions are essentially uniform in nature on charging at 25°C, attributed to the fact that there is a larger number of interstitial positions available in the hexagonal close-packed titanium structure. Both electrochemical and fusion measurements show that about all hydrogen is of the trapped variety in these materials on electrolytic charging and the stability of the metal hydrides is quite high. Stress has the effect of releasing trapped hydrogen to form the mobile variety, a result which may require a re-evaluation of the effect of stress on hydrogen movement. The structures of pure titanium and the titanium alloys are also discussed as well as the nature of bonding in these alloys.

TP-2847 September 1988

More on Exact State Reconstruction in Deterministic Digital Control Systems. Michael E. Polites. Structures and Dynamics Laboratory. N88-28177

This paper presents a special form of the Ideal State Reconstructor for deterministic digital control systems which is simpler to implement than the most general form. The Ideal State Reconstructor is so named because: if the plant parameters are known exactly, its output will exactly equal, not just approximate, the true state of the plant and accomplish this without any knowledge of the plant's initial state. Besides this, it adds no new states or eigenvalues to the system. Nor does it affect the plant equation for the system in any way; it affects the measurement equation only. It is characterized by the fact that discrete measurements are generated every T/N seconds and input into a multi-input/multi-output moving-average (MA) process. The output of this process is sampled every T seconds and utilized in reconstructing the state of the system.

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EDWARDS, JIM Boeing Aerospace
HOLMES, ROY
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NEIN, MAX
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APPROVAL

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Compiled by Joyce E. Turner

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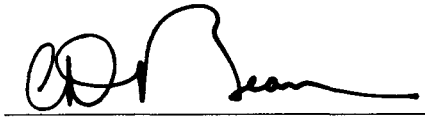

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☆U.S. GOVERNMENT PRINTING OFFICE: 1989 - 631-056/00022